POWERPC OPTIMIZATION FOR REAL-TIME SCENE GENERATION: PARALLEL RENDERING FOR ENVIRONMENTAL SUPPORT OPTV2 DEVELOPMENT AND DATA SUPPORT DISTRIBUTED INTERACTIVE SIMULATION TECHNOLOGIES IN AFTER-ACTION REVIEW SUPPORT (DISTAR)

Wolfgang Baer, Research Assistant
Department of Computer Science
Sponsor: U.S. Army Test and Experimentation Command and PARSYTEC, Inc.

OBJECTIVE: Development of Sensor Realistic Real-Time Battlefield Simulator on commercial off-the-shelf (COTS) PC Equipment.

SUMMARY: Research during 1997 concentrated on the development of parallel ray trace algorithms for rapid generation of video realistic tactical battlefield simulation in a symmetric multiprocessor pentium- based PC. Research activities included the development of benchmark tests of networked pentium-based machines under the Linux and NT operating systems to determine the feasibility of using low cost commercial components to host high speed simulations. Specifically, the questions of rapid access of large arrays in main memory of symmetric multiprocessing configurations and efficient cache utilizations were addressed.

PUBLICATIONS:

Baer, W., "Real-Time Scientific Rendering Simulation for General Sensors," Spring Simulation Interoperability Workshop, Workshop Papers, IST-CF-97-01.2, IST, Orlando, FL, Vol. I, p. 535, 3 March 1997.

CONFERENCE PRESENTATION:

Baer, W., "Real Time Scientific Rendering Simulation for General Sensors," Spring Simulation Interoperability Workshop, Orlando, FL, March 1997.

THESIS DIRECTED:

Decato, S. W., "Parallel Processing Performance Evaluation of Mixed T10/T100 Ethernet Topologies on Linux Pentium Systems," Master's Thesis, Naval Postgraduate School, March 1997.

OTHER:

Baer, W., "Software Performance Modeling in PC Clusters," 6SMP Performance Analysis for Battlefield Visualization, 1997.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Battlefield Simulation, Parallel Processing, Ray Tracing

TASK FORCE XXI DATABASE SUPPORT SMART GRID TO VECTOR CONVERSION TERRAIN DATABASE CONVERSION TOOLS FOR JANUS/PEGASUS/MODSAF

Wolfgang Baer, Research Assistant
Department of Computer Science
Sponsor: U.S. Test and Experimentation Command and U.S. Army Training and Doctrine Analysis Command, Monterey

OBJECTIVE: Develop rapid terrain database generation capability on low cost PC equipment.

SUMMARY: Development of a terrain data creation toolbox which allowed standard data sources (DTED and SPOT) to be integrated with high resolution aerial photographs was expanded to allow input of commercial high resolution digital elevation data, local photography, and battlefield data sources. The toolbox research provides for rapid terrain generation including automated pattern recognition, stereo elevation extraction, and model-based feature identification. The utilization of image differencing as an approach for rapid terrain generation is one of the central themes of this research.

PUBLICATION:

Baer, W., "Toward Standards for Interoperability Simulation Reuse for Infrared (IR)," Fall Simulation Interoperability Workshop, Workshop Papers, IST-CF-97-043, IST Vol. II, p. 983, Orlando, FL, 8-12 September 1997.

CONFERENCE PRESENTATION:

Baer, W., "Toward Standards for Interoperability Simulation Reuse for Infrared (IR)," Fall Simulation Interoperability Workshop," Orlando, FL, Fall 1997.

DoD TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Terrain Database, Pattern Recognition, Machine Vision

BINARY UNIVERSAL METEOROLOGICAL DATA FORMAT DEVELOPMENT PHASE II

Wolfgang Baer, Research Assistant
Department of Computer Science
Sponsor: Naval Research Laboratory-Monterey

OBJECTIVE: Development of meteorologic encoder for the Naval Research Lab in Monterey.

SUMMARY: This contract was the second phase of a software design and development project leading to the delivery of an operational encoder for transmission of WMSO standard data known as GREB and BUFFER. These formats represent variable field and message information. The research required to develop efficient coding schemes for self-descriptive compact transmission of large arrays an sparse matrices.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Meteorology Data Standards, Data Transmission Format

SOFTWARE REASONING FOR COMBINING CHANGES TO SOFTWARE SYSTEMS

Valdis Berzins, Professor
Department of Computer Science
Sponsor: U.S. Army Artificial Intelligence Center

OBJECTIVE: The goal of the project is to apply previously developed theories of software design structure and develop a prototype decision support tool for software maintenance in the context of the Computer-Aided Prototyping System (CAPS).

SUMMARY: In 1997, the project completed the implementation and evaluation of a method for combining changes to hierarchical design structures. This method is the first of its kind with the ability to automatically detect and automatically recover from conflicts between the independently developed changes to be combined. This is possible in this context because of the following special characteristics of hierarchical software design structures: (1) the extension of the design structure lattice to a Brouwerian algebra preserves the least upper bounds of the original lattice and (2) the semantics of the

design (although not its understandability) is independent of the hierarchical structure. The first property ensures that reasoning in the extended algebraic structure is also valid with respect to the embedded model of proper designs, and the second ensures that weakening approximations with respect to the lattice structure do not throw away practically vital information.

The initial experimental assessments of the implementation indicate that the method is computationally tractable and produces reasonable results. The project has also developed a method for merging changes to black-box specifications for software modules, expressed using logic [Berzins 98]. This introduces a boolean difference operator into the logic, which has not been extensively studied and has somewhat surprising properties. Experience with applying the method shows that changes that intuitively seem independent may not actually be independent. The conjecture is that this may be relevant to the feature interaction problem in software requirements.

PUBLICATIONS:

Berzins, V., "Recombining Changes to Software Specifications," to appear, *Journal of Systems and Software,* August 1998.

Berzins, V., "Merging Changes to Software Specifications," *Proceedings of the 1997 ARO Workshop on Requirements Targeting Software and System Engineering - Towards a Scientific Basis,* Munich, Germany, 12-14 October 1997.

Leonard, T., Berzins, V., Luqi, and Holden, M., "Gathering Requirements from Remote Users," *Proceedings of the 9th International Conference on Tools with Artificial Intelligence*, Newport Beach, CA, 3-8 November, 1997, pp. 462-471.

Luqi and Berzins, V., "Engineering Automation for Computer Based Systems," *Proceedings of the 1997 Workshop on Virtual Universities,* Newport Beach, CA, 4 November 1997.

CONFERENCE PRESENTATIONS:

Luqi, "Merging Changes to Software Specifications," Army Research Office Workshop on Requirements Targeting Software and Systems Engineering, Bernried, Germany, 13 October 1997.

Luqi, "Why Worry about Change Merging?" Workshop on Virtual Universities, Newport Beach, CA, 4 November 1997.

THESIS DIRECTED:

Keesling, W., "Decomposition Recovery Extension to the Computer-Aided Prototyping System (CAPS) Change-Merge Tool," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Automated Reasoning, Software Evolution, Conflict Resolution

REQUIREMENTS ANALYSIS FOR CVX

Valdis Berzins, Professor
Department of Computer Science
Sponsor: Naval Sea Systems Command

OBJECTIVE: This goal of this research is to reduce the risks of the CVX effort via analysis of selected aspects of the requirements. The current requirements for the CVX have been prioritized using the QFD method, which is based on the Analytic Hierarchy Process (AHP) method. Recent work at the Naval Postgraduate School has applied the AHP method in the context of software requirements and has developed a number of improvements. The objectives of the project is to apply the CVX data to the several improved algorithms for the AHP method developed at the Naval Postgraduate School and compared the results to those of the original study.

SUMMARY: Recent work at the Naval Postgraduate School has applied the AHP method in the context of software requirements and has developed a number of improvements. These improvements have been incorporated to the AHP method, together with the algorithm for the exact eigenvector calculations in the MATLAB program. The software developed in this project provides requirements analysts with new improved algorithms to prioritize the CVX UNTL task requirements. Experimental results showed that, under the conventional linear weighting scheme, the original study produced highly accurate computations.

The exponential weighting scheme provides another way to combine the pairwise importance ratings. It was shown, by comparing the difference between the original input matrices and the reconstructed consistent matrices, that the exponential weighting scheme gives results which match the original input matrices better, in the sense that the numerical measures of degrees of inconsistency for the individual pairwise judgements are smaller. It is recommended that CVX UNTL domain experts review the priorities and ranking produced by the exponential weighting to see if they are indeed closer to human expectations. The reconstructed consistent matrices and the difference matrices for the linear weighting scheme also pinpoint potential areas of inconsistency in the original input matrices. CVX UNTL domain experts should review the results for reducing potential risks of the CVX effort.

PUBLICATIONS:

Berzins, V., "Requirements Analysis for the CVX," Project Report, CVX Program Office, 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Analytic Hierarchy Process (AHP) Software Requirements, Prototyping

AUTOMATION SUPPORT FOR SOFTWARE EVOLUTION

Valdis Berzins, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

OBJECTIVE: The objective of this research is to design a system for automating the configuration management needed to keep track of the evolution of a software prototyping during a typical application of the evolutionary software prototyping method supported by the Computer-Aided Prototyping System (CAPS).

CAPS is an integrated software development environment aimed at rapidly prototyping hard real-time embedded software systems, such as missile guidance systems, space shuttle avionics systems, robots, automated factories, telecommunications systems, computer-controlled vehicles, and computer-controlled consumer appliances such as microwave ovens and sewing machines.

SUMMARY: The technical objective is to create, validate, and implement an integrated set of formal models and algorithms that can be used to enable computer-aided evolutionary development of a wide-range of complex software applications, including real-time and embedded systems.

This is important for computer-aided software evolution because this type of software is particularly resistant to change, is often safety- and mission-critical, and may have to be changed on short notice when external conditions change. Unaided modifications to these systems are often times consuming and unreliable because timing constraints introduce heavy dependencies between otherwise logically unrelated parts of the software. A valid, accurate, and coherent set of formal models is a needed first step in the detailed design of the desired decision support tools.

PUBLICATIONS:

Berzins, V., "Merging Changes to Software Specifications," *Proceedings of the 1997 ARO Workshop on Requirements Targeting Software and System Engineering - Towards a Scientific Basis*, Munich, Germany, 12-14 October 1997.

Berzins, V., Ibrahim, O., and Luqi, "A Requirements Evolution Model for Computer-Aided Prototyping," *Proceedings of the 9th International Conference on Software Engineering and Knowledge Engineering*, Madrid, Spain, pp. 38-47, 17-20 June 1997.

Leonard, T., Berzins, V., Luqi, and Holden, M., "Gathering Requirements from Remote Users," *Proceedings of the 9th International Conference on Tools with Artificial Intelligence*, Newport Beach, CA, pp. 462-471.3-8 November 1997.

Luqi and Berzins, V., "Engineering Automation for Computer Based Systems," *Proceedings of the 1997 Workshop on Virtual Universities*, Newport Beach, CA, 4 November 1997.

CONFERENCE PRESENTATIONS:

Berzins, V., "Merging Changes to Software Specifications," Army Research Office Workshop on Requirements Targeting Software and Systems Engineering, Bernried, Germany, 13 October 1997.

Berzins, V., "Why Worry about Change Merging?" Workshop on Virtual Universities, Newport Beach, CA, 4 November 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer-Aided Software, Decision Support Tool

TRAINING SPATIAL KNOWLEDGE ACQUISITION USING VIRTUAL ENVIRONMENTS

Rudolph P. Darken, Assistant Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: To study navigation and spatial orientation phenomena associated with real and virtual environments and determine how virtual environments can be used to improve navigation ability in the real world.

SUMMARY: The importance of navigation and wayfinding in virtual environments is paramount to the success and eventual acceptance of this technology as an operational and training tool for the Navy. It will be shown that virtual environments can be used to acquire spatial knowledge of a specific real space. This is largely a training transfer study. The work will also involve the investigation of environmental features and perceptual stimuli and their role in navigation and wayfinding so that an understanding of how to degrade the fidelity of a virtual environment without substantially degrading navigation performance can be made. These concepts will be extended to training general navigation skills, including map usage (perspective transformation) and landmarking abilities.

PUBLICATION:

Darken, R.P., Cockayne, W.R., and Carmein, D., "The Omni-Directional Treadmill: A Locomotion Device for Virtual Worlds," *Proceedings of UIST '97*, pp. 213-221, 1997.

CONFERENCE PRESENTATIONS:

Darken, R.P., Cockayne, W.R., and Carmein, D., "The Omni-Directional Treadmill: A Locomotion Device for Virtual Worlds," UIST 1997.

Darken, R.P., "Acquiring Spatial Knowledge from Virtual Worlds," Invited lecture at the Oregon Center for Advanced Technology Education, Oregon Graduate Institute, Beaverton, OR, 21 November 1997.

Darken, R.P., "Designing for Wayfinding in Virtual Environments," Panel on Designing Interactive Multimedia, ACM Multimedia '97, Seattle, WA, 12 November 1997.

Darken, R.P., "Navigation in Virtual Environments," Course lecture in Applied Virtual Reality, SIGGRAPH 97, Los Angeles, CA, 4 August 1997.

Darken, R.P., "Wayfinding in Virtual Worlds," Invited lecture at the American Psychological Association Annual Meeting, Chicago, IL, 18 August 1997.

Darken, R.P., "Navigating in Virtual Worlds: Wayfinding and Locomotion Issues," Lecture at the NASA Ames Research Center, Moffett Field, CA, 22 May 1997.

Darken, R.P., "Navigation in Virtual Worlds: Wayfinding and Locomotion in Real and Not-So-Real Environments," Lecture at the Carnegie Mellon University Human-Computer Interaction Institute Seminar Series, Pittsburgh, PA, 16 April 1997.

Darken, R.P., "Navigation in Virtual Worlds: Performance Issues," Panel on Performance Issues in Virtual Environments, Virtual Reality Annual International Symposium (VRAIS) 97, Albuquerque, NM, 5 March 1997.

THESIS DIRECTED:

Banker, W. P., "Virtual Environments and Wayfinding in the Natural Environment," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Environments, Cognitive Science, Psychology, Training

3-D AUDITORY DISPLAYS IN AIRCRAFT SIMULATION AND TRAINING

Rudolph P. Darken, Assistant Professor
Department of Computer Science
Sponsor: Naval Air Systems Command

OBJECTIVE: To study the use of spatial acoustic displays in aviation simulation training from the perspective of pilot performance and training transfer.

SUMMARY: The aim of this research is to explore some of the basic issues necessary to integrate virtual audio technology into new and existing training systems and operational platforms in naval aviation. It has already been shown that the capability of presenting compelling, accurate 3D spatial audio in real time is possible. It has not, however, been shown that this capability can and should be used for Naval aviation training and/or operations. The working hypothesis is that the application of virtual auditory cues can enhance team performance by increasing the combatants' awareness of other participants in the simulation, both real and computer generated. To prove this concept, these auditory displays within the cockpit as well as between cockpits in a multi-user distributed interactive simulation (DIS) scenario will be integrated. This system will then be evaluated in a number of ways to determine if the hypothesis is indeed correct. At this point, a position to determine procedures for the integration of spatial audio in Naval air training and operations in a more general way will be possible.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Environments, Cognitive Science, Psychology, Training

TRAINING NAVIGATION USING VIRTUAL ENVIRONMENTS

Rudolph P. Darken, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To study navigation and spatial orientation phenomena associated with real and virtual environments and determine how virtual environments can be used to improve navigation ability in the real world.

SUMMARY: The importance of navigation and wayfinding in virtual environments is paramount to the success and eventual acceptance of this technology as an operational and training tool for the Navy. It will be shown that virtual environments can be used to acquire spatial knowledge of a specific real space. This is largely a training transfer study. The work will also involve the investigation of environmental features and perceptual stimuli and their role in navigation and wayfinding so that an understanding of how to degrade the fidelity of a virtual environment without substantially degrading navigation performance can be made. These concepts will then be extended to training general navigation skills, including map usage (perspective transformation) and landmarking abilities.

THESIS DIRECTED:

Banker, W. P., "Virtual Environments and Wayfinding in the Natural Environment," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Environments, Cognitive Science, Psychology, Training

WARRIOR NETWORK EXPERIMENTS

John Falby, Lecturer
David Pratt, Associate Professor
Paul Barham, Computer Specialist
Department of Computer Science
Sponsor: Simulation, Training, and Instrumentation Command

OBJECTIVE: The graphics and video laboratory of the Department of Computer Science at NPS is currently conducting research on inserting articulated human ICONS into distributed interactive simulation (DIS). The work on Warrior Network is focused on dismounted infantry tasks using a mobility platform for the human/computer interaction

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Graphics, Computer Networks, Human Factors

SCHEDULING ATM TRAFFIC FOR BATTLEFIELD AWARENESS AND DATA DISSEMINATION (BADD)

Debra Hensgen, Associate Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To simulate several heterogeneous scheduling algorithms and a split IP protocol in the Battlefield Awareness and Data Dissemination (BADD) ATM environment using OpNet. To determine which algorithms permit the environment to deliver acceptable quality of service. Two students, Clark Benton and Michael Lemanski were involved as well.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Heterogenous, Distributed, Networking, Simulation

HETEROGENEOUS PROCESSING PROGRAM INITIATIVE

Debra Hensgen, Associate Professor
Taylor Kidd, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To build software, with students, for acquired hardware to establish a high quality, military-relevant, heterogeneous processing program at the Naval Postgraduate School. The goal is that after the first two years, the program will be well known for its significant achievements, will produce results that will make computing/networking a stronger force multiplier, and will be self-sustaining.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Modeling and Simulation, Other (Metacomputing)

KEYWORDS: Heterogeneous, Distributed, Parallel, Processing, Metacomputing

ADVANCED CONTROL SOFTWARE ARCHITECTURE FOR AUTONOMOUS VEHICLES

Michael Holden, Commander, USN
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To produce advanced control software for autonomous vehicles within the framework of structured software engineering. This proposed research work is in advanced control software for autonomous vehicles within the framework of structured software engineering, especially as it pertains to combining the ongoing work of the NPS Computer-Aided Prototyping System (CAPS) and the Center for Autonomous Underwater Vehicle (AUV) Research.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles-Ships and Watercraft, Computing and Software, Human Systems Interface

KEYWORDS: Software Engineering, Robotics, Autonomous Underwater Vehicles

SUPPORT FOR INFORMATION WARFARE-PROTECT (IW-P) PROGRAM IN THE NAVAL POSTGRADUATE SCHOOL (NPS) CENTER FOR INFORMATION SECURITY RESEARCH (CISR) COMPUTER SECURITY LABORATORY

Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Naval Security Group

OBJECTIVE: The objective of this research is to support classes and thesis research in the area of information warfare-protect (IW-P) through the acquisition of laboratory equipment for the Naval Postgraduate School Center for Information Systems Security (INFOSEC) Studies and Research. Emphasis has been placed upon the initiation of research into network security issues associated with switches and routers using ATM technology with IP-tags. This is an ongoing project.

SUMMARY: Several security vulnerabilities in ATM technology with IP-tags have been identified. In this ongoing research effort, conducted with G. Xie of the Naval Postgraduate School's Computer Science Department, and two thesis

students, the development of protocols and protection techniques which can insure the confidentiality and integrity of ATM connections are being investigated. A small ATM network is being established in the Computer Security Laboratory which will allow examination of performance characteristics of the protocols being investigated.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, Active Networks, INFOSEC

AN ENVIRONMENT FOR DEVELOPING SECURE SOFTWARE

Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This work is part of a continuing project aimed at developing new techniques for statically analyzing code, that is targeted for remote execution, for secure flow violations. The algorithm will attempt to construct a proof, for a given program, in a sound flow logic, thereby establishing that the program is secure. The algorithm will permit remote code, written in Web-based languages like Java and JavaScript, to be analyzed prior to execution in order to determine whether it can be executed safely.

SUMMARY: In 1997, Volpano and Smith (Florida International University), completed a decidable secure flow logic for a core imperative language with procedures. The logic is a type system with subtyping that arises due to treating upward information flow. Interesting subtype relationships exist. For instance, the subtype relation is covariant in expression types, but contravariant in command (statement) types. A type inference algorithm was developed for the logic. Type inference in this setting is interesting due to procedures which have principal types that effectively document how these procedures can be called securely in some context. The algorithm was proved sound and complete relative to the logic, and prototyped by Smith in Scheme.

PUBLICATION:

Volpano, D. and Irvine, C.E., "Secure Flow Typing," *Computers and Security*, Vol. 16, No. 2, pp. 137-144, 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Programming Languages, Information Flow

DEVELOPMENT OF INFORMATION SYSTEMS SECURITY (INFOSEC) COURSEWARE AND VIDEOS

Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: Defense Information Systems Agency

OBJECTIVE: This project is to support the development of an INFOSEC course entitled Management of Secure Systems and the transformation of video tapes of the Invited Lecture Series on INFOSEC topics into Web-based material that can be exported beyond the Naval Postgraduate School to DoD, U.S. Government, and academia. The second aspect of the project is of a continuing nature.

SUMMARY: A course entitled, "Management of Secure Systems," has been developed and class sections were taught in both the summer and fall quarters of calendar year 1997. A laboratory involving a risk assessment is an integral part of the course. Two local institutions permitted students to conduct risk assessments of networked systems: California State University at Monterey Bay and Fleet Numerical Meteorology and Oceanography Center.

This research also provided partial support for the ACM Workshop on Education in Computer Security, held in January 1997. International in scope, the workshop described the relationship between academe and industry in the area of INFOSEC education. Academic programs ranged from those addressing ethics to highly technical studies in computer science. Challenges identified included formulating courses and curricula, development of classroom materials, and career prospects in INFOSEC.

A series of lectures on INFOSEC topics were video taped. Techniques to place all or portions of the lectures on the World Wide Web were investigated. These included the digitization of the videos, video editing, and presentation formats such as HTML, compact disk, and edited videos. Video editing permits a broad range of compression and enhancement options. Recommendations were made for balancing the video and audio parameters against memory and remote delivery requirements.

PUBLICATION:

Irvine, C.E., "The First ACM Workshop on Education Computer Security," *ACM Special Interest Group on Security and Audit Control Review,* Vol. 15, No. 2, pp. 3-5, 1997.

THESIS DIRECTED:

Umentum, B., "Mass Dissemination of INFOSEC via the World Wide Web," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, High Assurance Systems, INFOSEC, Education, Research

SUPPORT FOR NAVAL POSTGRADUATE SCHOOL (NPS) INFORMATION SYSTEMS SECURITY (INFOSEC) RESEARCH PROGRAM, PHASE II

Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: The objective of this research is to support the development of a Center for Research and Education in Information Systems Security at NPS. The effort is intended to provide military officers basic and advanced education in the area of computer and information system security. This continuing program is intended to be a continuing source of high-quality information systems security research focussing on problems of critical importance to military services.

SUMMARY: In support of research, this on-going project permitted a requirements specification and high level architecture to be developed for a multilevel local area network (LAN). A key feature of this network will be the concentration of security policy enforcement for critical mandatory policies in a high assurance server based upon an existing high assurance commercial-off-the shelf product. Client workstations will be untrusted and will run popular commercial operating systems and commercial office productivity products. A key element in the LAN design is the establishment of a trusted path between the client and the server to provide high confidence authentication of the user to the system and of the system to the user. The use of a specialized controller card at the clients was identified as an effective technique to provide secure initialization, trusted path, and object-reuse services for client workstations.

Mail services were explored as an application suitable for adaptation to a multilevel client-server environment. A mail spooler was modified to provide a concept demonstration of multilevel mailboxes hosted on a high assurance platform enforcing a mandatory security policy.

A second investigation pursued under this research program was an analysis of commercially available encryption products for the protection of information designated as sensitive but unclassified (SBU). This includes information such as personnel records, medical data, and legal records, which must be protected in order to comply with the Privacy Act. A

result of this investigation was the development of an evaluation procedure for commercial encryption products. Using the procedure, products were scored using a variety of technical, ease-of-use, and service-related criteria.

Application-level security was the focus of the third investigation. The use of protocols to ensure the authenticity and confidentiality of interactions with protected servers in a web-based environment was examined. Issues associated with the integrity of downloaded code and the confidentiality of passwords were examined.

This research supported a broad effort in the area of computer security education. Work included the development or improvement of intermediate and advanced graduate courses in computer security, the dissemination of course materials using both traditional and electronic media, an invited lecture series on computer security topics. As part of the effort, a workshop on education in computer security education was initiated.

PUBLICATIONS:

Irvine, C.E., Warren, D. F., and Stemp, R., "Teaching Computer Security at a Department of Defense University," Naval Postgraduate School Technical Report, NPS-CS-97-002, April 1997.

Irvine, C.E., Warren, D. F., and Stemp, R., "The NPS CISR Graduate Program in INFOSEC Education: Six Years of Experience," *Proceedings of the 20th National Information Systems Security Conference*, Baltimore, MD, pp. 22-30, October 1997.

Irvine, C.E., "Challenges in Computer Security Education," *IEEE Software*, Vol. 14, No. 5, pp.110-111, 1997.

CONFERENCE PRESENTATIONS:

Irvine, C. E., "An Approach to Graduate Education in Computer Security," First ACM Workshop on Education in Computer Security, Monterey, CA, January 1997.

Irvine, C. E., "Internet Security? Only If You Know How," 10th Annual Federal Information System's Security Educators' Association Conference, Gaithersburg, MD, March 1997.

Irvine, C.E., Warren, D. F., and Stemp, R., "The NPS CISR Graduate Program in INFOSEC Education: Six Years of Experience," 20th National Information Systems Security Conference, Baltimore, MD, October 1997.

THESES DIRECTED:

Downey, J. P. and Robb, D. A., "Design of a High Assurance Multilevel Security Mail Server (HAMMS)," Master's Thesis, Naval Postgraduate School, September 1997.

Harris, R. and Buettner, R., "A Comparative Analysis of Commercial Off-the-Shelf Software for Use in Transmitting Sensitive but Unclassified Data," Master's Thesis, Naval Postgraduate School, September 1997.

Weldon, S. G., "Protocols for Secure Client-Server Applications in the Joint Maritime Command Information System," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, High Assurance Systems

CENTER FOR INFORMATION SYSTEMS SECURITY (INFOSEC) STUDIES AND RESEARCH

Cynthia E. Irvine, Assistant Professor
Department of Computer Science
Sponsor: National Security Agency

OBJECTIVE: The objective of this research is to provide ongoing support to the development of the NPS Center for Information Systems Security (INFOSEC) Studies and Research at NPS Center for Information Security Research (CISR). The Center will serve DoN, DoD, and U.S. Government needs in INFOSEC through: curriculum development, a trusted systems laboratory, faculty development, a visiting professor program, an invited lecture series, academic outreach, and work with graduates. The intent of the program is to develop a comprehensive approach to INFOSEC education and research that better serves the needs of the warfighter and the intelligence community.

SUMMARY: In support of research, this project continued an effort to build a high assurance multilevel secure local area network (LAN). A controller board for use at untrusted client workstations has been identified. It will provide trusted path, workstation initialization, and object reuse facilities. The board, currently used for media encryption to workstation disk drives, will be modified to provide the trusted computing base extension functionality identified as necessary for a multi-level secure LAN.

This research also supported the initiation of an effort to explore the use of split address space technology to provide high assurance support of threads in an environment intended to create partially ordered privilege domains. This base will be used to support a system for the dynamic adaptation and retooling of software.

PUBLICATIONS:

Chin, S-K., Irvine, C.E., and Frinke, D., "An Information Security Education Initiative for Engineering and Computer Science," Naval Postgraduate School Technical Report, NPS-CS-97-003, Naval Postgraduate School, December 1997.

Irvine, C.E., "Naval Postgraduate School Center for INFOSEC Studies and Research: Teaching the Science of Computer Security," *Proceedings MILCOM '97*, Monterey, CA, November 1997.

CONFERENCE PRESENTATION:

Irvine, C.E., "Naval Postgraduate School Center for INFOSEC Studies and Research: Teaching the Science of Computer Security," MILCOM '97, Monterey, CA, November 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer Security, Network Security, High Assurance Systems, INFOSEC, Education, Research

A ROBOTIC SYSTEM FOR UNEXPLODED ORDNANCE (UXO)/MINE DETECTION

Yutaka Kanayama, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School-Institute of Joint Warfare Analysis

OBJECTIVES: The objective of this proposal is to support the activities of the interdisciplinary multi-faculty group project, "A Semi-Autonomous Land/Aerial Robotics System for UXO/Mine Detection and Clearing," More specifically, this proposal is for supporting some of the equipment and travel expense to run the research.

SUMMARY: The robotic vehicle "Shepherd" was constructed in September 1996. This vehicle has a unique feature of having the three degrees of freedom in motion as opposed to most wheeled-land vehicles. In this year, the first attempt of developing the real-time operating system for Shepherd was planned and was successfully completed. As a result, a live videotape demo of several complex operations was taken. This project was successfully executed by Professor Kanayama

and Professor Yun, Department of Electrical and Computer Engineering, and three master's students from the Departments of Computer Science and Physics. The software development steps consist of: (1) developing a small operating kernel, (2) developing a basic set of motor control and encoder reading, and (3) developing a set of high level motion behaviors. These projects were completely successful by September 1997.

PUBLICATIONS:

Kanayama, Y. and Hartman, B., "Smooth Local Path Planning for Autonomous Vehicles," *International Journal of Robotics Research*, Vol. 16, No. 3, pp. 263-284, 1997.

Kanayama, Y. and Fahroo, F., "A New Line Tracking Method for Nonholonomic Vehicles," *International Journal of Robotics Research*, 1997.

Kanayama, Y. and Fahroo, F., "A New Line Tracking Method for Nonholonomic Vehicles," *Proceedings of the IEEE International Conference on Robotics and Automation,* Albuquerque, NM, pp. 2908-2913, 21-27 April 1997.

Kanayama, Y., "Rotary Vehicle That Moves with Three Degrees of Freedom," *Proceedings of the International Conference on Advanced Robotics,* Monterey, CA, pp. 713-718, 7-9 July, 1997.

Kanayama, Y. and Fahroo, F., "A Circle Tracking Method for Nonholonomic Vehicles," *Proceedings of the Fifth IFAC Symposium on Robot Control,* Nantes, France, pp. 551-558,3-5 September, 1997

Morsy, K.A. and Kanayama, Y., "A New Straight Edge Detection Algorithm Using Direction-Controlled Edge Tracking and Random Hitting," *Proceedings of the IEEE International Symposium on Computational Intelligence in Robotics and Automation*, Monterey, CA, pp. 398-405, 10-11 July 1997.

Yoneda, K., Kanayama, Y., and Suzuki, K., "Gait and Foot Trajectory Planning for Versatile Motions of a Six Legged Robot," *Journal of Robotic Systems*, Vol.14, No. 2, pp. 121-133, 1997.

THESES DIRECTED:

Mays, E. and Reid, F., "Motion Control of a Rotary Vehicle," Master's Thesis, Naval Postgraduate School, September 1997.

Morsy, K., "An Efficient Model-Based Image Understanding Method for an Autonomous Vehicle," Ph.D. Dissertation, Naval Postgraduate School, September 1997.

PATENT APPLICATION:

Kanayama, Y., "Continuous Curvature Motion Control of Autonomous Vehicles," being prepared.

DoD TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Ground Vehicles

KEYWORDS: Autonomous Vehicle, Mine/UXO Detection and Clearing, Omni-Directional Vehicle, Motion Control, Human Interface

MANAGEMENT SYSTEM FOR HETEROGENEOUS NETWORKS (MSHN)

Taylor Kidd, Associate Professor
Debra Hensgen, Associate Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: A research and design effort directed at solving the fundamental problems associated with and creating a distributed metacomputer.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Heterogeneous, Distributed Computing, Data Staging, Metacomputing

RE-ARCHITECTING DEFENSE TECHNICAL INFORMATION CENTER

Ted Lewis, Professor
Department of Computer Science
Sponsor: Defense Technical Information Center

OBJECTIVE: To redesign the computing infrastructure for the Defense Technical Information Center at Ft. Belvoir, VA.

SUMMARY: Interview, analyze, specify, and design the next-generation systems architecture for the DoD's premier technical report center. All reports (and NPS theses) go to DTIC where they are scanned into a computer database for indexing and cataloging. The problem is, the web has changed how this system should work. The recommendations will be used to re-architect DTIC into a web-based digital library system of the future.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Digital Library, Text Retrieval, Information Retrieval, Data Warehousing, Data Mining, Workflow Management

ARTIFICIAL INTELLIGENCE (AI) SYSTEM FOR DETECTION AND CLASSIFICATION OF UNEXPLODED ORDNANCE (UXO)/LAND MINES

Nelson Ludlow, Major, USAF
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This project supports an artificially-intelligent robot system to detect and classify UXO and land mines. This is an interdisciplinary multi-faculty group project. Neural networks and blackboard architectures will be developed to first detect UXO and land mines, and then determine which UXO/land mine the system is looking at, based upon the sensor data of magnetometers and visual camera. Several existing systems can detect if something metallic is on the ground, however, no one yet has a working system that can classify what the robot is looking at.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface

KEYWORDS: Artificial Intelligence, Neural Networks, Blackboard Architecture, UXO, Land Mines

APPLICATIONS AND FUTURE DIRECTIONS OF THE INTERNET

G.M. Lundy, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The internet is rapidly changing the way of doing business for the military, industry, and also personal communications all over the world. Of interest is the future directions the internet will take, how it may be used to the advantage of the military, as well as in other ways and in problems it may have; for example, security and overloading of the communications channels. A student is also exploring the possibilities. The main objectives are to investigate: (1) future directions of the internet; (2) applications, especially for the military; and (3) problems which have or are expected to occur.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Internet, Communications

GUIDELINES AND SOFTWARE ARCHITECTURE FOR RISK ASSESSMENT IN SOFTWARE REUSE

Luqi, Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This project will mitigate risks in software reuse by developing guidelines for risk assessment and develop a software architecture for performing the software risk assessment. Risks in software reuse include unreliable components, expensive searching, lack of compatibility, and brittleness. These risks must be managed to avoid cost/schedule overruns and inadequate software systems. Areas to be considered are user interface, decision support, and techniques for managing and retrieving the reusable software components with efficient algorithms in developing and validating the guidelines and software architecture.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Reuse, Risk Assessment, Software Architecture

FORMAL MODELS USED FOR AUTOMATION IN SOFTWARE DEVELOPMENT

Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Research Office

OBJECTIVE: The objectives of the proposed research are the design of an integrated set of formal models and methods for automating a wide range of design and development tasks for real-time systems.

SUMMARY: The project focused on automation of design activities that appear in an evolutionary prototyping approach to software development. This research used a set of state-of-the-art formal methods in software engineering to construct a cohesive set of formal models. These models were used to create and to unify automated processes for computer-aided prototyping.

Mathematical models for implementing a set of automated and integrated software tools were developed. This research combines very-high-level specification abstractions and concepts with formal real-time models, automated management of software design data and human resources, transformations, change merging, and automated retrieval of reusable software components to provide automated methods for generating real-time programs and for coordinating teams of developers.

PUBLICATIONS:

Berzins, V., Ibrahim, O., and Luqi, "A Requirements Evolution Model for Computer-Aided Prototyping," *Proceedings of the 9th International Conference on Software Engineering and Knowledge Engineering*, Madrid, Spain, pp. 38-47, 17-20 June 1997.

Leonard, T., Berzins, V., Luqi, and Holden, M., "Gathering Requirements from Remote Users," *Proceedings 9th International Conference on Tools with Artificial Intelligence*, Newport Beach, CA, pp. 462-471, 3-8 November 1997.

Luqi, and Goguen, J. "Formal Methods: Promises and Problems," *IEEE Software*, Vol. 14, No. 1, pp. 73-85, January 1997.

Luqi, and Berzins, V., "Engineering Automation for Computer-Based Systems," *Proceedings of the 1997 Workshop on Virtual Universities*, Newport Beach, CA, 4 November 1997.

Luqi, "Formal Models and Prototyping," *Proceedings of the 1997 ARO Workshop on Requirements Targeting Software and System Engineering - Towards a Scientific Basis*, Munich, Germany, 12-14 October 1997.

CONFERENCE PRESENTATIONS:

Luqi, "Formal Models and Prototyping," ARO Workshop on Requirements Targeting Software and Systems Engineering, Bernried, Germany, 13 October 1997.

Luqi, "Engineering Automation for Computer Based-Systems," Workshop on Virtual Universities, Newport Beach, CA, 4 November 1997.

THESES DIRECTED:

Bailey, F. and Robbins, C., "Real-Time, Remotely Controlled, Unmanned, Surface Combatant (RTRCUSC) Using the Internet," Master's Thesis, Naval Postgraduate School, September 1997.

Bell, A., "Documentation for Computer-Aided Prototyping System (CAPS) User Interface and Graphic Editor," Master's Thesis, Naval Postgraduate School, March 1997.

Coleman, M., "CHANNEL CAT: A Tactical Link Analysis Tool," Master's Thesis, Naval Postgraduate School, September 1997.

Dabose, M., "Autonomous Agents for Digital Network Maximization," Master's Thesis, Naval Postgraduate School, September 1997.

Evans, J., "Project Scheduling Tool," Master's Thesis, Naval Postgraduate School, September 1997.

Garingo, G., "Java Based Data Connectivity," Master's Thesis, Naval Postgraduate School, September 1997

Herman, J., "Improving Syntactic Matching for Multi-Level Filtering," Master's Thesis, Naval Postgraduate School, September 1997.

Howell, M., "Analysis of a 3-Tier Distributed Architecture for the Sector Anti-Air Warfare Center," Master's Thesis, Naval Postgraduate School, September 1997.

Keesling, W., "Decomposition Recovery Extension to the Computer-Aided Prototyping System (CAPS) Change-Merge Tool," Master's Thesis, Naval Postgraduate School, September 1997.

Leonard, T., “Front Loaded Accurate Requirements Engineering (FLARE): A Requirements Analysis Concept for the 21st Century,” Master’s Thesis, Naval Postgraduate School, September 1997.

Mock, C., “A Syntax Directed Editor for the Computer-Aided Prototyping System (CAPS),” Master’s Thesis, Naval Postgraduate School, September 1997.

Plutchak, B., “The Design of an Interface Editor for the Computer-Aided Prototyping System,” Master’s Thesis, Naval Postgraduate School, September 1997.

Ray, W., “Automatic Layout Techniques for the Graphical Editor in the Computer Aided Prototyping System,” Master’s Thesis, Naval Postgraduate School, September 1997.

Rusin, D., “Application of the Rapid Computer Aided Prototyping System (CAPS) in the Development of a Sudden Infant Death Syndrome (SIDS) Monitor,” Master’s Thesis, Naval Postgraduate School, June 1997.

Yetkin, E. and Sotero, S., “Re-Engineering Portability of Computer Aided Prototyping System (CAPS),” Master’s Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computer-Aided Prototyping System (CAPS), Software Engineering

COMPUTER-AIDED PROTOTYPING APPLIED TO ARMY TACTICAL MISSILE SYSTEM (ATACMS)

Luqi, Professor
Department of Computer Science
Sponsor: U.S. Army Research Laboratory

OBJECTIVE: The Computer-Aided Prototyping System (CAPS) is an integrated software development environment aimed at rapidly prototyping hard real-time systems. The objective of the proposed project is to use CAPS to evaluate and refine the requirements for the ATACMS. This will improve the quality of the product and its interoperability across different branches of DoD.

SUMMARY: The project has established the feasibility of using CAPS for modeling and simulation to evaluate integration of large-scale systems like ATACMS. The top level model of the ATACMS has been completed and evaluated. The top level prototype has more than 5000 lines of code. CAPS is able, either indirectly or through derived attributes, to represent requirements. The automatic scheduling, graphical translation and code generation are essentially error-free. CAPS can support more detailed modeling to assess and remove risks to data interoperability across the diverse links planned for ATACMS.

THESIS DIRECTED:

Angrisani, D. and Whitbeck, G., “Software System Requirements for the Army Tactical Missile System,” Master’s Thesis, Naval Postgraduate School, September 1996.

TECHNICAL REPORT:

Luqi, “Using CAPS for ATACMS,” Project Report, Army Research Laboratory, 1997.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Computer-Aided Prototyping System (CAPS), Army Tactical Missile System (ATACMS)

COMPUTER-AIDED PROTOTYPING OF REAL-TIME SYSTEMS

Luqi, Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: This research is aimed at computer-aided prototyping tools or designing real-time software systems. The main research problems are developing abstract models and implementation techniques based on formalized specifications.

SUMMARY: Many subjects were worked on related to software automation: program generation from specifications, real-time scheduling, computer-aided reuse, design databases, software evolution, the coupling between graphical interfaces and partial automatic inference of software designs, and the first prototyping language for real-time systems (PSDL - Prototype System Description Language) based on formal semantics. The project received donations of hardware and software from many industrial organizations to build the lab, and has produced 20 journal papers, 51 conference papers, chapters in seven books, seven Ph.D dissertations, and 49 Master's theses from FY91 through FY97.

PUBLICATIONS:

Berzins, V., Ibrahim, O., and Luqi, "A Requirements Evolution Model for Computer Aided Prototyping," *Proceedings of the 9th International Conference on Software Engineering and Knowledge Engineering*, Madrid, Spain, pp. 38-47, 17-20 June 1997.

Leonard, T., Berzins, V., Luqi, and Holden, M., "Gathering Requirements from Remote Users," *Proceedings 9th International Conference on Tools with Artificial Intelligence*, Newport Beach, CA, pp. 462-471, 3-8 November 1997.

Luqi and Goguen, J., "Formal Methods: Promises and Problems," *IEEE Software*, Vol. 14, No. 1, pp. 73-85, January 1997.

Luqi, and Berzins, V., "Engineering Automation for Computer Based Systems," *Proceedings of the 1997 Workshop on Virtual Universities*, Newport Beach, CA, 4 November 1997.

Luqi, "Formal Models and Prototyping," *Proceedings of the 1997 ARO Workshop on Requirements Targeting Software and System Engineering - Towards a Scientific Basis*, Munich, Germany, 12-14 October 1997.

CONFERENCE PRESENTATIONS:

Luqi, "Formal Models and Prototyping," ARO Workshop on Requirements Targeting Software and Systems Engineering, Bernried, Germany, 13 October 1997.

Luqi, "Engineering Automation for Computer-Based Systems," Workshop on Virtual Universities, Newport Beach, CA, 4 November 1997.

THESES DIRECTED:

Bailey, F. and Robbins, C., "Real-Time, Remotely Controlled, Unmanned, Surface Combatant (RTRCUSC) Using the Internet," Master's Thesis, Naval Postgraduate School, September 1997.

Bell, A., "Documentation for Computer-Aided Prototyping System (CAPS) User Interface and Graphic Editor," Master's Thesis, Naval Postgraduate School, March 1997.

Coleman, M., “CHANNEL CAT: A Tactical Link Analysis Tool,” Master’s Thesis, Naval Postgraduate School, September 1997

Dabose, M., “Autonomous Agents for Digital Network Maximization,” Master’s Thesis, Naval Postgraduate School, September 1997.

Evans, J., “Project Scheduling Tool,” Master’s Thesis, Naval Postgraduate School, September 1997.

Garingo, G., “Java Based Data Connectivity,” Master’s Thesis, Naval Postgraduate School, September 1997

Herman, J., “Improving Syntactic Matching for Multi-Level Filtering,” Master’s Thesis, Naval Postgraduate School, September 1997.

Howell, M., “Analysis of a 3-Tier Distributed Architecture for the Sector Anti-Air Warfare Center,” Master’s Thesis, Naval Postgraduate School, September 1997.

Keesling, W., “Decomposition Recovery Extension to the Computer-Aided Prototyping System (CAPS) Change-Merge Tool,” Master’s Thesis, Naval Postgraduate School, September 1997.

Leonard, T., “Front Loaded Accurate Requirements Engineering (FLARE): A Requirements Analysis Concept for the 21st Century,” Master’s Thesis, Naval Postgraduate School, September 1997.

Mock, C., “A Syntax Directed Editor for the Computer Aided Prototyping System (CAPS),” Master’s Thesis, September 1997.

Plutchak, B., “The Design of an Interface Editor for the Computer-Aided Prototyping System (CAPS),” Master’s Thesis, Naval Postgraduate School, September 1997.

Ray, W., “Automatic Layout Techniques for the Graphical Editor in the Computer-Aided Prototyping System (CAPS),” Master’s Thesis, Naval Postgraduate School, September 1997.

Rusin, D., “Application of the Rapid Computer-Aided Prototyping System (CAPS) in the Development of a Sudden Infant Death Syndrome (SIDS) Monitor,” Master’s Thesis, Naval Postgraduate School, June 1997.

Yetkin, E. and Sotero, S., “Re-Engineering Portability of Computer Aided Prototyping System,” Master’s Thesis, Naval Postgraduate School, March 1997.

TECHNICAL REPORTS:

Luqi, “Computer Aided Prototyping of Real-Time Systems,” Final Report, CCR-9058453, National Science Foundation, December 1997.

OTHER: CAPS Software

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Prototype System Description Language (PSDL), Real-Time Scheduling, Computer-Aided Reuse, Design Databases, Software Evolution

AUTONOMOUS AGENTS APPLICABLE TO THE REAL-TIME RETARGETING PROGRAM

Luqi, Professor
Department of Computer Science
Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The objective of the project is to enable retargeting in real-time as new threats emerge, while utilizing existing tactical communications links. The proposed approach is to use autonomous software agents to manage network resources to increase effective throughput, by a combination of differential transmission techniques, data compression, and global network load balancing.

SUMMARY: A key issue for real-time retargeting is transmitting the required information to the systems that must respond via existing tactical communications links within tight timing requirements. Current tactical networks have limited speed and are already straining their transmission capacity. Thus real-time retargeting in this environment requires improving bandwidth utilization with the goal of optimizing the actual information transmitted.

Many current network strategies, both commercial and tactical, rely on repeated broadcast of standardized messages. As a result, much available bandwidth is wasted on the repeated transmission of redundant information. The approach taken to maximize specific network node throughput on a digital network is a three-layer paradigm, managed by an embedded autonomous software agent located at each network node. The first layer consists of a network specific strategy for reducing the message content. The second layer is a frame-by-frame analysis of the reduced message content to determine the best compression method to be applied to the information itself (MPEG, etc.). The third layer is a packaging strategy to maximize the packaging of each specific network packet.

The first phase of a proof-of-concept prototype has been implemented. Initial results, via a network simulation, have demonstrated a quantitative 300% plus increase in effective information throughput capability, utilizing the same physical bandwidth. Since this approach is an embedded technique, existing network hardware, software, and standards remain uneffected. A side benefit witnessed is increased network responsiveness due to increased information flow in a timely manner. In terms of processing time required, the cost is more than compensated by increased information transfer capacity that can be used to realize future requirements for real-time retargeting.

THESIS DIRECTED:

Dabose, M., "Autonomous Agents for Digital Network Maximization," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Autonomous Agents, Networks, Capacity Optimization

AUTONOMOUS AGENTS FOR DIGITAL NETWORK MAXIMIZATION

Luqi, Professor
Department of Computer Science
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this effort is to make more effective use of the limited bandwidth available on DoD Links. The proposed approach is to use autonomous software agents to manage network resources to increase effective throughput, by a combination of differential transmission techniques, data compression, and global network load balancing. An architecture for such agents will be described and assessed.

SUMMARY: An important problem arising from the increased sharing of information across networks is bandwidth constraint. The limitations of communications channels in the transmission of voluminous information is the singular bottleneck dictating processing capability and robustness of current and future distributed systems. Bandwidth utilization with the goal of optimizing the actual information transmitted, has to date, been ignored. Many of the current network strategies,

both commercial and tactical, rely on the repeated broadcast of a standardized message. As a result, much available bandwidth is wasted on the repeated transmission of redundant information. The specific approach taken to maximize specific network node throughput on a digital network is a three-layer paradigm, managed by an embedded autonomous software agent located at each network node.

The first layer consists of a network specific strategy for reducing the message content. The second layer is a frame-by-frame analysis of the reduced message content to determine the best compression method to be applied to the information itself (MPEG, etc.). Finally, a packaging strategy to maximize the packaging of each specific network packet. The first phase of a proof-of-concept prototype has been implemented. Initial results, via a network simulation, have demonstrated a quantitative 300% plus increase in effective information throughput capability, utilizing the same bandwidth. Since this approach is an embedded technique, existing network hardware, software, and standards remain uneffected. A side benefit witnessed is increased network responsiveness due to increased information flow in a timely manner. In terms of processing time required, the cost is more than compensated for by increased network efficiency. The net result is a more efficient and responsive network capability.

THESIS DIRECTED:

Dabose, M., "Autonomous Agents for Digital Network Maximization," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Autonomous Agents, Networks, Capacity Automization

AN EXPERIMENTAL STUDY OF SOFTWARE ARCHITECTURES AND SOFTWARE REUSE FOR CONTROL OF UNMANNED UNDERWATER VEHICLES

R.B. McGhee, Professor
Department of Computer Science
A.J. Healey, Professor
Department of Mechanical Engineering
Sponsor: National Science Foundation and Naval Postgraduate School

OBJECTIVE: The goal of this project was to investigate alternative software architectures for control of unmanned underwater vehicles, and to find effective means for archiving and retrieving software modules used to implement such software systems. The research was conducted in cooperation with the Monterey Bay Aquarium Research Institute (MBARI) and INRIA, a French Government Research Institute.

SUMMARY: This was a three-year project which began in 1994 and terminated 30 June 1997. During calendar year 1997, much of the work was focused on further development of the "Rational Behavior Model" (RBM) software architecture, and its testing, using both the physical Naval Postgraduate School *Phoenix* autonomous underwater vehicle (AUV) and its real-time simulation model. This work was successful. A small AUV navigation system (SANS) based on a combination of a low cost strapped down inertial measurement unit (IMU) and a miniaturized global positioning system (GPS) receiver was successfully tested. An advanced "point and click" mission planning software expert system was developed which allows mission specialists to automatically generate mission control software without any manual coding. The attainment of these results meets the primary objectives of the original project plan and provides a basis for the development of more advanced AUVs specifically configured for various shallow-water tasks such as mine hunting, coastal environmental monitoring, etc.

PUBLICATION:

Davis, D.T., Brutzman, D.P., Leonard, B.J., and McGhee, R.B., "Operational Mission Planning and Mission Control for the *Phoenix* Autonomous Underwater Vehicle," accepted for publication in *IEEE Journal of Oceanic Engineering*, 1998.

THESES DIRECTED:

Knapp, R. G., "Calibration and Evaluation of Waterspeed Indicator and Compass for the Small AUV Navigation Filter," Master's Thesis, Naval Postgraduate School, December 1997.

Roberts, R.L., "Implementation and Evaluation of an Integrated Self-Contained GPS/INS Shallow-Water AUV Navigation System (SANS)," Master's Thesis, Naval Postgraduate School, March 1997.

Thorne, R.L., "Asynchronous Data Fusion for AUV Navigation Using Extended Kalman Filtering," Master's Thesis, Naval Postgraduate School, March 1997.

DoD KEY TECHNOLOGY AREA: Other (Military Robotics)

KEYWORDS: Robotics, Mine Countermeasures, Autonomous Underwater Vehicles (AUV)

NPSNET: JANUS SOLDIER STATION-PHASE 1 AND 2

David Pratt, Associate Professor
Department of Computer Science
Sponsor: U.S. Army Training and Doctrine Analysis Command

OBJECTIVE: The graphics ad video laboratory of the Department of Computer Science at NPS is currently conducting research in the connection of the JANUS combat model to the distributed interactive simulation (DIS) environment. The focus of this project is the integration of the JANUS combat model routines into NPSNET to produce a single integrated system. This project will leverage off existing and supporting JANUS research efforts.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Combat Models, Graphics Artificial Intelligence, Computer Networks

TECHNICAL SUPPORT FOR THE JOINT SIMULATION SYSTEM (JSIMS) JOINT PROGRAM

David Pratt, Associate Professor
Department of Computer Science
Sponsor: Joint Simulation System Joint Project Office

OBJECTIVE: To act as the JSIMS Technical Director.

SUMMARY: As the JSIMS System continues to grow, it has become apparent that there is a need for a Technical Director who acts as an advisor to the project management on technical issues. The principal investigator was selected as such an individual. In this capacity, Dr. Pratt represented the program on several managerial and technical panels and forums. He was also instrumental in providing technical guidance and helping to set up the program.

PUBLICATIONS:

Powell, E. and Pratt, D., "The Joint Simulation System Architecture: A Foundation for Future Training Systems," *Proceedings of the 19th Interservice Industry Training Systems and Education Conference*, Orlando, FL, December 1997.

Pratt, D. and Beasley, Drew W., "Issues In Modeling And Simulation: Policies And Technologies," *Proceedings of the 1997 Winter Simulation Conference*, Atlanta, GA, December 1997.

Pratt, D., Peabody, C., and Liby, G., "The Joint Simulation System Software Development Process," *Proceedings of the Ninth Software Technology Conference*, Salt Lake City, UT, April 1997.

DoD TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Manpower, Personnel, and Training

KEYWORDS: Combat Models, Graphics, Synthetic Environments, Artificial Intelligence, Computer Networks

ARTIFICIAL INTELLIGENCE FOR TERRAIN-DATABASE INTEGRATION

Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: U.S. Army Training and Doctrine Analysis Command

OBJECTIVE: To investigate, using ideas from artificial intelligence, how to simplify the integration of diverse terrain databases.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Terrain Databases, Data Structures, Software Integration

RESOLUTION OF DATA-SOURCE INCOMPATIBILITIES IN TERRAIN DATABASES

Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: Information Management Support Center

OBJECTIVE: To write software to intelligently resolve incompatibilities between different terrain databases.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Terrain Databases, Data Structures, Software Integration

AUTOMATIC INDEXING OF PICTURES ON INTERNET PAGES

Neil C. Rowe, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: To build a prototype system that finds the photographs on Internet/World Wide Web pages, finds their captions, and indexes them.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interfaces

KEYWORDS: Captions, Photographs, Parsing, Artificial Intelligence

DEVELOPMENT OF THE GEOLOCATION WORKBENCH

Timothy J. Shimeall, Associate Professor
Department of Computer Science
Herschel H. Loomis, Professor
Department of Electrical and Computer Engineering
Sponsor: Navy Engineering Logistics Office

OBJECTIVE: This proposal will support the development of a facility to develop and analyze geolocation algorithms in a project-nonspecific manner. The outcome of this two-year project will support interoperability between existing signal data collection systems and increase the ability to adapt existing data analysis systems to new use.

DoD KEY TECHNOLOGY AREA: Command, Control, and Comunications

KEYWORDS: Geolocation Algorithms, Signal Processing

REFINEMENT OF SOFTWARE SAFETY ANALYSIS TOOLS

Timothy J. Shimeall, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: This research will refine existing safety analysis tools, improving the reliability and general functionality of the tools. These tools are currently of interest to a number of Navy and DoD projects.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Safety Analysis Tools

ONLINE POLYMORPHIC TYPE INFERENCE IN IMPERATIVE LANGUAGES

Dennis Volpano, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: This work is part of a continuing project in which the primary objective is to investigate new type theories for imperative programming languages.

SUMMARY: This project is a joint effort with Geoffrey Smith at the Florida International University (FIU). The project ended at FIU in 1996, but NPS was granted a one-year extension in October 1996 to complete the remaining work originally proposed. During the first two years of the project, an ML-style polymorphic type system was designed for a dialect of C, called Polymorphic C. The type system allows these operations in their full generality, so that programmers need not give up the flexibility of C to gain the benefits of ML-style polymorphism and rigorous type reconstruction. A type soundness theorem was proved that gives a rigorous and useful characterization of well-typed Polymorphic C programs in terms of what can go wrong when they are evaluated.

This theorem, called a progress theorem, could not be proved with a natural semantics since such a semantics cannot cope with partial executions and failure. In 1996, Smith introduced a new style of semantics based on transitions between partial derivation trees. The semantics was formulated as a formal system of inference rules by Volpano in 1997. The formal system is called a Natural Transition Semantics.

PUBLICATION:

Smith, G. and Volpano, D., "A Sound Polymorphic Type System for a Dialect of C," to appear in *Science of Computer Programming*, Vol. 32, Nos. 2-3, 1998.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Programming Languages, Semantics, Static Analyses

AN ENVIRONMENT FOR DEVELOPING SECURE SOFTWARE

Dennis Volpano, Associate Professor
Cynthia Irvine, Assistant Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: This work is part of a continuing project aimed at developing new techniques for statically analyzing code, that is targeted for remote execution, and for secure flow violations. The algorithm will attempt to construct a proof, for a given program, in a sound flow logic, thereby establishing the program as secure. The algorithm will permit remote code, written in Web-based languages like Java and JavaScript, to be analyzed prior to execution in order to determine whether it can be executed safely.

SUMMARY: In 1997, Volpano and Smith (Florida International University), completed a decidable secure flow logic for a core imperative language with procedures. The logic is a type system with subtyping that arises due to treating upward information flow. Interesting subtype relationships exist. For instance, the subtype relation is covariant in expression types, but contravariant in command (statement) types. A type inference algorithm was developed for the logic. Type inference in this setting is interesting due to procedures which have principal types that effectively document how these procedures can be called securely in some context. The algorithm was proved sound and completed relative to the logic and prototyped by Smith in Scheme.

PUBLICATIONS:

Volpano, D. and Irvine, C., "Secure Flow Typing," *Computers and Security*, Vol. 16, No. 2, pp. 137-144, 1997.

Volpano, D. and Smith, G., "A Type-Based Approach to Program Security," *Proceedings of the 7th International Joint Conference on the Theory and Practice of Software Development*, Lecture Notes in Computer Science 1214, pp. 607-621, 1997.

Volpano, D. and Smith, G., "Language Issues in Mobile Program Security," accepted for publication in a special issue of Lecture Notes in *Computer Science on Mobile Agents and Security*.

CONFERENCE PRESENTATIONS:

Volpano, D., "A Type-Based Approach to Program Security," 7th International Joint Conference on the Theory and Practice of Software Development, Lille, France, April 1997.

Volpano, D., "Pursuing Provable Privacy in Programs," DARPA Principal Investigator's Meeting, Lake Tahoe, CA, August 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Secure Information Flow, Remote Evaluation

TYPE SYSTEMS FOR SECURE REMOTE EVALUATION

Dennis Volpano, Associate Professor
Department of Computer Science
Sponsor: National Science Foundation

OBJECTIVE: This is a joint project with Geoffrey Smith at the Florida International University (FIU). The work is part of a continuing project aimed at investigating the role of programming language design and type systems in ensuring the security of servers in remote evaluation systems. The long-term objective is to identify how languages should be designed to guarantee provable confinement properties for all programs expressed in these languages.

SUMMARY: We developed an extension of a secure-flow type system that treats two easy ways that sequential programs can leak private information, specifically, nontermination and exceptions. In a purely synchronous programming language, either can be used to leak data covertly. We discovered that these two ways could be prohibited in a type system by typing the continuations of partial-recursive constructs and partial operations as functions over public data only. The system can also be modified to rule out all covert timing channels in an asynchronous language by typing continuations of branch statements in the same way. The resulting system is more restrictive and it is not clear whether it is still useful in practice.

PUBLICATION:

Volpano, D. and Smith, G., "Eliminating Covert Flows with Minimum Typings," *Proceedings of the 10th IEEE Computer Security Foundations Workshop*, pp. 156-168.

CONFERENCE PRESENTATIONS:

Volpano, D., "Eliminating Covert Flows with Minimum Typings," 10th IEEE Computer Security Foundations Workshop, Rockport, MA, June 1997.

Volpano, D., "Secure Information Flow in a Multi-Threaded Imperative Language," Workshop on Security and Languages, DEC Systems Research Center, Palo Alto, CA, October 1997.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Type Systems, Remote Evaluation, Security

WORKSHOP ON PROVABLY-SECURE PROGRAMMING

Dennis Volpano, Associate Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The aim of the workshop was to explore the relationship between the design of programming languages and security models.

SUMMARY: The workshop was held in Monterey, CA, 26-28 March 1997. Its official title is the "1997 Foundations for Secure Mobile Code Workshop." The 25 attendees from industry and academia were asked to prepare position statements which were provided in advance to all attendees on the web. Statements addressed basically two types of security problems: protecting servers from mobile code and protecting mobile code from malicious servers. The latter problem was viewed as more intractable, given the need for mobile code to rely on an execution platform of some sort. Participants presented their positions and discussion followed. All presentations and discussions were recorded for future reference, however, a final report was not written.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORD: Security

DESIGN AND IMPLEMENTATION OF AIRPAC FINANCIAL ANALYSIS TOOL II (AFAST)

Thomas Wu, Associate Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: In 1994, VADM Spane (Commander, Naval Air Forces Pacific) requested a study to assess the financial management capabilities of the AIRPAC command. One of the many recommendations provided by the study is the development of a financial information system capable of providing timely and consistent financial information for the AIRPAC. The AFAST system was built as a result. However, the system has met the original goals only partially. The system has many limitations, which must be rectified in order for the system to be usable in highly data-intensive, client/server environment. Without upgrading the current system, growing needs of the AIRPAC cannot be met. The proposal is to redesign and implement an improved version of the AFAST.

DoD KEY TECHNOLGY AREA: Other (Financial Management)

KEYWORDS: AFAST, Financial Management

NETWORK SUPPORT FOR MULTIMEDIA APPLICATIONS

Goeffrey G. Xie, Assistant Professor
Department of Computer Science
Sponsor: Naval Postgraduate School

OBJECTIVE: The goal of the research is to design networks that guarantee application-level quality of services (QoS) to multimedia applications.

SUMMARY: The three active projects are: (1) Design and implementation of SAAM: a novel network management system for support of integrated services in the Next Generation Internet (NGI). The research has identified the stringent requirements of integrated services and developed a server-based and hierarchical active network management architecture; (2) Design and implementation of an application-level guaranteed statistical service for real-time traffic. The research has developed admission control and loss management algorithms for such a service based on a novel traffic model for real-time traffic; and (3)
Design and implementation of a security framework suitable for fast IP routing based on ATM switching. The tradeoff between routing speed and security vulnerability in current IP/ATM proposals was identified.

PUBLICATIONS:

Lam, S.S. and Xie, G.G, "Group Priority Scheduling," *IEEE/ACM Transactions on Networking*, Vol. 5, No. 2, pp. 205-218, April 1997.

Lam, S.S. and Xie, G.G, "Burst Scheduling Networks," *Performance Evaluation*, Vol. 31, pp. 133-157, December 1997.

CONFERENCE PAPERS:

Xie, G.G. and Lam, S.S., "Real-time Block Transfer Under a Link Sharing Hierarchy," *Proceedings of the IEEE INFOCOM '97*, Kobe, Japan, April 1997.

Xie, G.G. and Lam S.S., "Admission Control and Loss Management for an Application-Level Statistical Service," *Proceedings of the 1997 IEEE International Conference on Network Protocols*, Atlanta, GA, October 1997.

CONFERENCE PRESENTATIONS:

Xie, G.G. and Lam, S.S., "Real-time Block Transfer Under a Link Sharing Hierarchy," IEEE INFOCOM '97, Kobe, Japan, 4 April 1997.

Xie, G.G. and Lam S.S., "Admission Control and Loss Management for an Application-Level Statistical Service," 1997 IEEE International Conference on Network Protocols, Atlanta, GA, 29 October 1997.

TECHNICAL REPORT:

Kresho, J., Hensgen, D., Kidd, T., and Xie, G., "Determining the Accuracy Required in Resource Load Prediction to Successfully Support Application Agility," Naval Postgraduate School, NPS-CS-98-001, December 1997.

THESES DIRECTED:

Klein, D., Mallory, C., and Safstrom, D., "Analysis, Design, and Implementation of a Web-Based Training System for Multi-Criteria Decision Support, Integrating Hypertext, Multimedia-Based, Case Studies and Training Software," Master's Thesis, Naval Postgraduate School, September 1997.

Lemanski, M. and Benton, J. "Simulation for SmartNet Scheduling of Asynchronous Transfer Mode Virtual Channels," Master's Thesis, Naval Postgraduate School, June 1997.

Umentum, B., "Mass Sessemination of INFOSEC Lectures via the Web," Master's Thesis, Naval Postgraduate School, September 1997.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications

KEYWORDS: Network, Multimedia, Quality-of-Service (QoS), Real-Time, Security

NPSNET-V: RAPIDLY CONFIGURABLE VIRTUAL WORLD

Michael J. Zyda, Professor
Department of Computer Science
Sponsor: National Imagery Mapping Agency

OBJECTIVE: The goal of this proposal is: (1) to architect and begin the implementation of the next generation of NPSNET, NPSNET-V; (2) to continue the work on terrain paging; (3) to continue the work in servicing the external NPSNET visual simulation user community; and (4) to perform leading edge research into terrain database quality and real-time utilization.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: NPSNET, Synthetic Environments, Virtual Environments

RAPIDLY RECONFIGURABLE VIRTUAL ENVIRONMENT NETWORK PROTOCOLS

Michael J. Zyda, Professor
Department of Computer Science
Donald Brutzman, Assistant Professor
Undersea Warfare Academic Group
Sponsor: Office of Naval Research

OBJECTIVE: Research in the area of human interaction in virtual environments is essential as a complimentary effort to NPSNET as well as to the VE research community at large. This proposal will outline plans for a research facility dedicated to this area and the directions to pursue in the coming years.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORD: Research, Engineering, Technology, Synthetic Environments, Distributed Interactive Simulation, Virtual Environments

NPSNET-HUMAN: INSERTING THE HUMAN INTO THE NETWORKED SYNTHETIC ENVIRONMENT

Michael J. Zyda, Professor
David Pratt, Associate Professor
Department of Computer Science
Sponsor: Defense Advanced Research Projects Agency

OBJECTIVE: The Department of Computer Science at NPS has been developing low-cost, networked 3D visual simulation systems for the last eight years. The latest system, NPSNET-IV, utilizes commercial of-the-shelf workstations, terrain databases, and distributed interactive simulation (DIS) networking formats to produce a networked, 3D synthetic environment. This proposal is for an extension of the NPSNET project into the domain of placing humans into the synthetic environment; humans can walk over the ground, and through buildings. These humans will perform a variety of tasks, from dismounted infantry to medical corpsman training. The primary tasks of this project are to examine and utilize technologies useful for human interaction in the synthetic environment, and to provide DIS support for the primary contractor (UPENN). The application domain for this project is the training of medical corpsmen.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Computers, Software, Communications Networking, Environmental Effects, Dismounted Infantry, Medical Corpsman Training